US009152089B1

(12) **United States Patent**
Denton et al.

(10) **Patent No.: US 9,152,089 B1**
(45) **Date of Patent: Oct. 6, 2015**

(54) **PARTIAL INTERNAL SHUNT AND PARTIAL EXTERNAL SHUNT ASSEMBLY FOR A MAGNETIC ROLL OF A DUAL COMPONENT DEVELOPMENT ELECTROPHOTOGRAPHIC IMAGE FORMING DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/501,807**

(22) Filed: **Sep. 30, 2014**

(51) **Int. Cl.**
G03G 15/09 (2006.01)
G03G 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0942*** (2013.01); ***G03G 15/0898*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0817; G03G 15/0898; G03G 15/0942
USPC 399/104, 103
See application file for complete search history.

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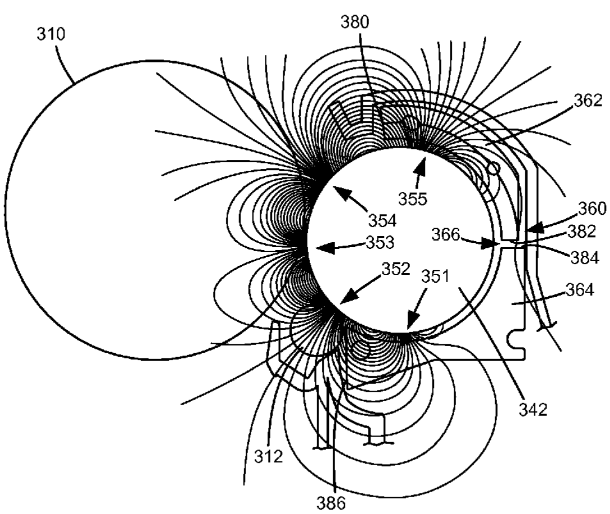
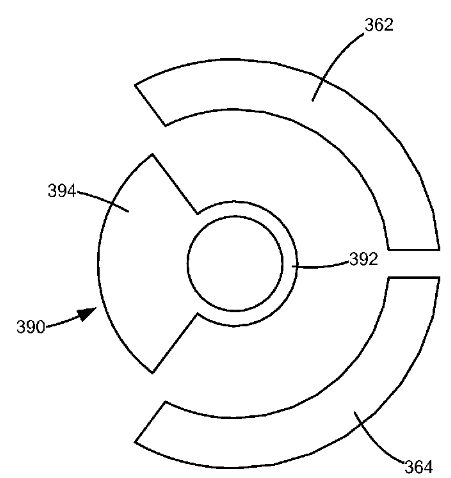
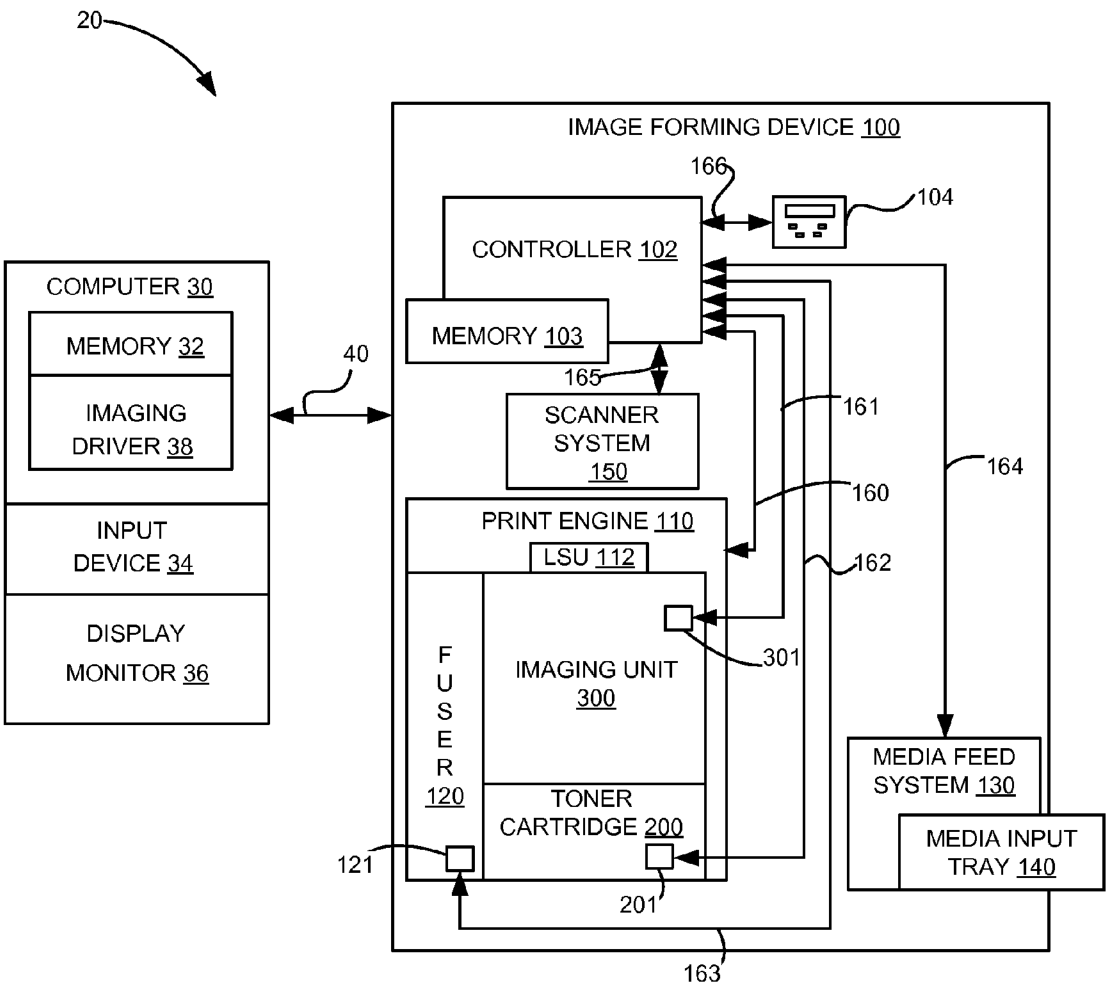
(57) **ABSTRACT**

A developer unit according to one example embodiment includes a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads. A magnetic roll includes a stationary core and a sleeve positioned around the core that is rotatable relative to the core. The stationary core includes at least one permanent magnet having circumferentially spaced magnetic poles. At least one external shunt is composed of a magnetically permeable metal and is positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core. At least one internal shunt is positioned at each axial end of the core inside of the sleeve. Each internal shunt has a shunt portion composed of a magnetically permeable metal and positioned along a second circumferential portion of the core.

10 Claims, 9 Drawing Sheets



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INPUT DEVICE 34
DISPLAY MONITOR 36
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IMAGE FORMING DEVICE 100
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CONTROLLER 102
MEMORY 103
165
SCANNER SYSTEM 150
161
164
160
PRINT ENGINE 110
LSU 112
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FUSER 120
IMAGING UNIT 300
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TONER CARTRIDGE 200
MEDIA FEED SYSTEM 130
MEDIA INPUT TRAY 140
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201
163

FIGURE 1

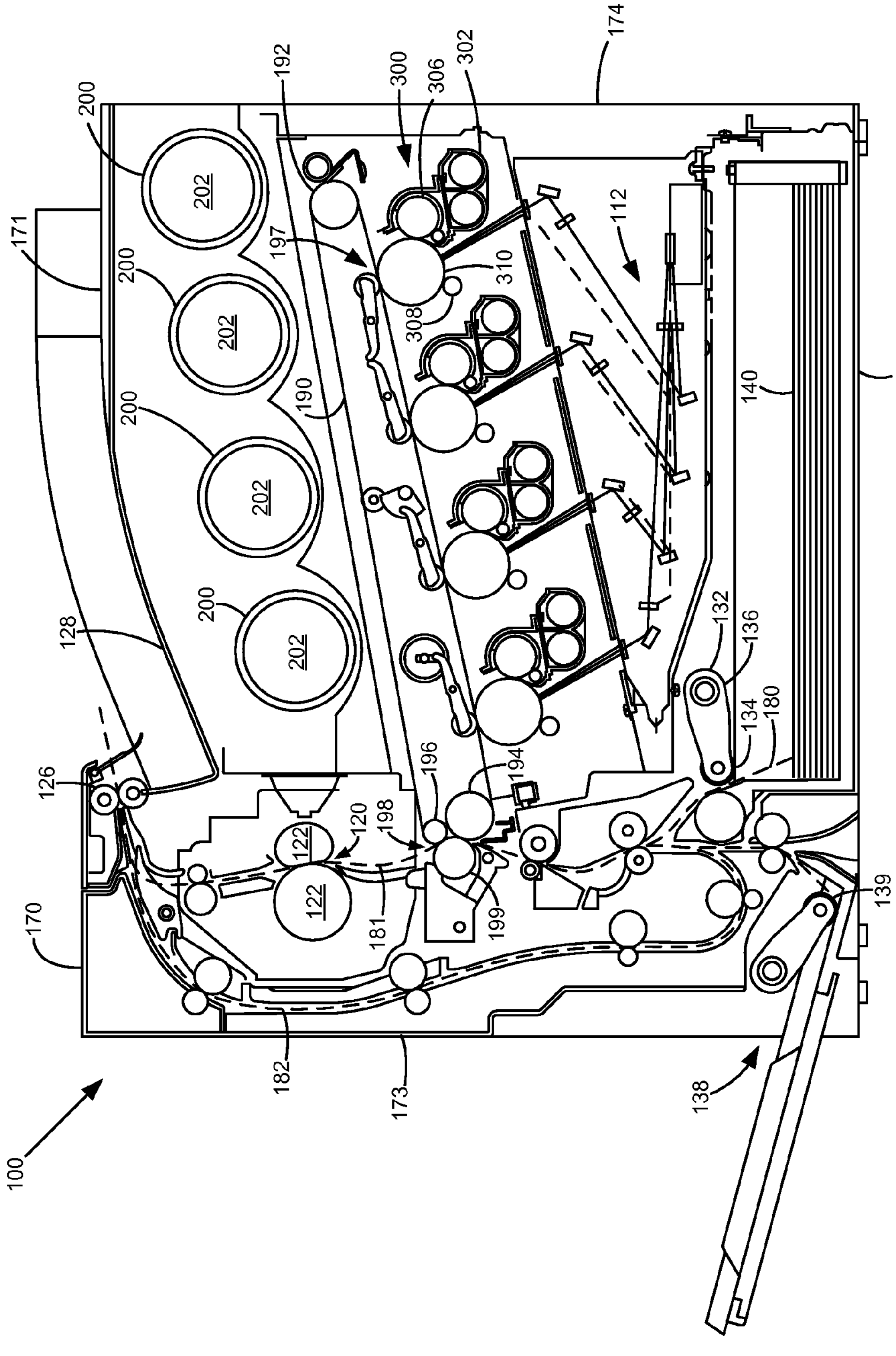
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FIGURE 2

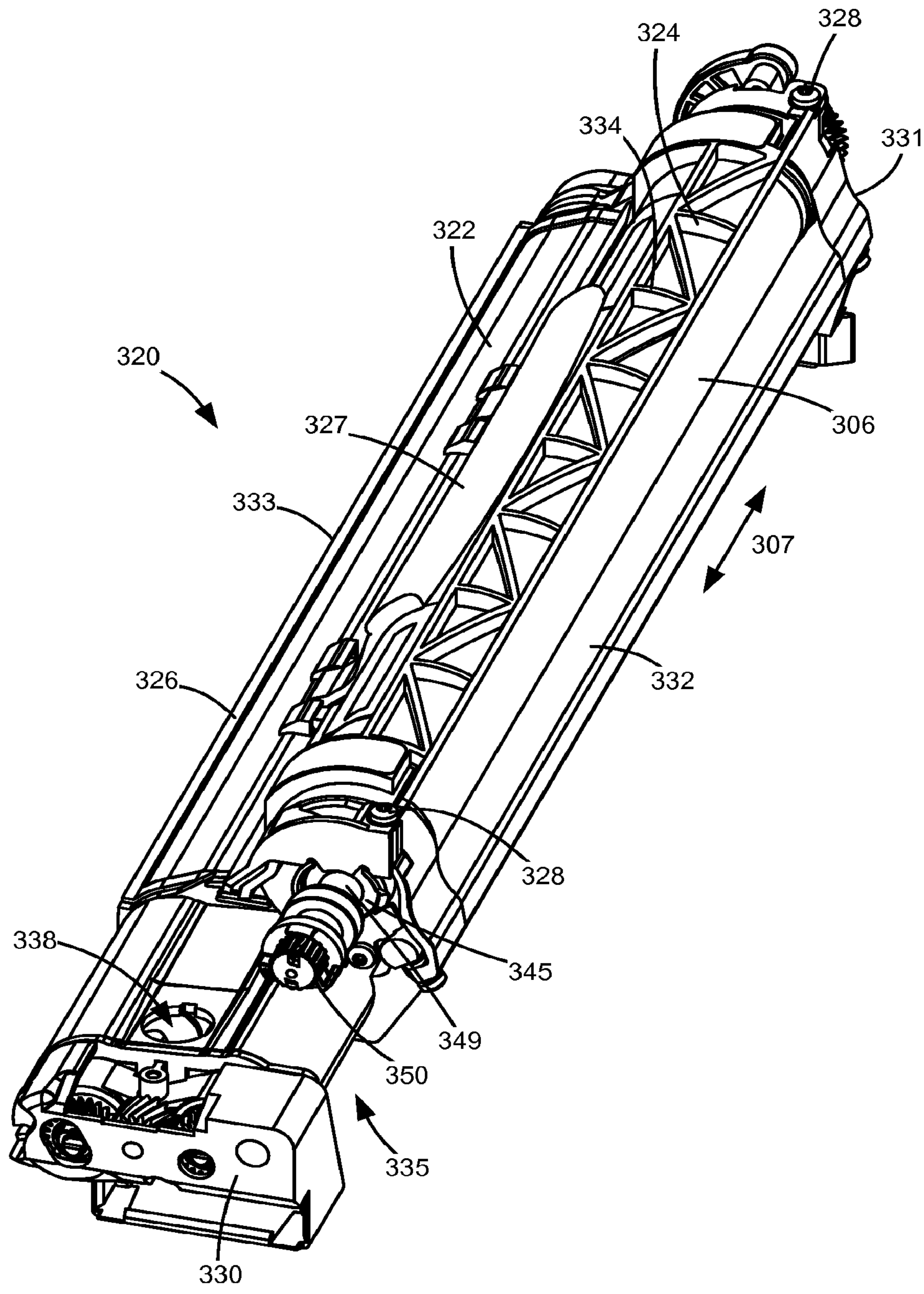
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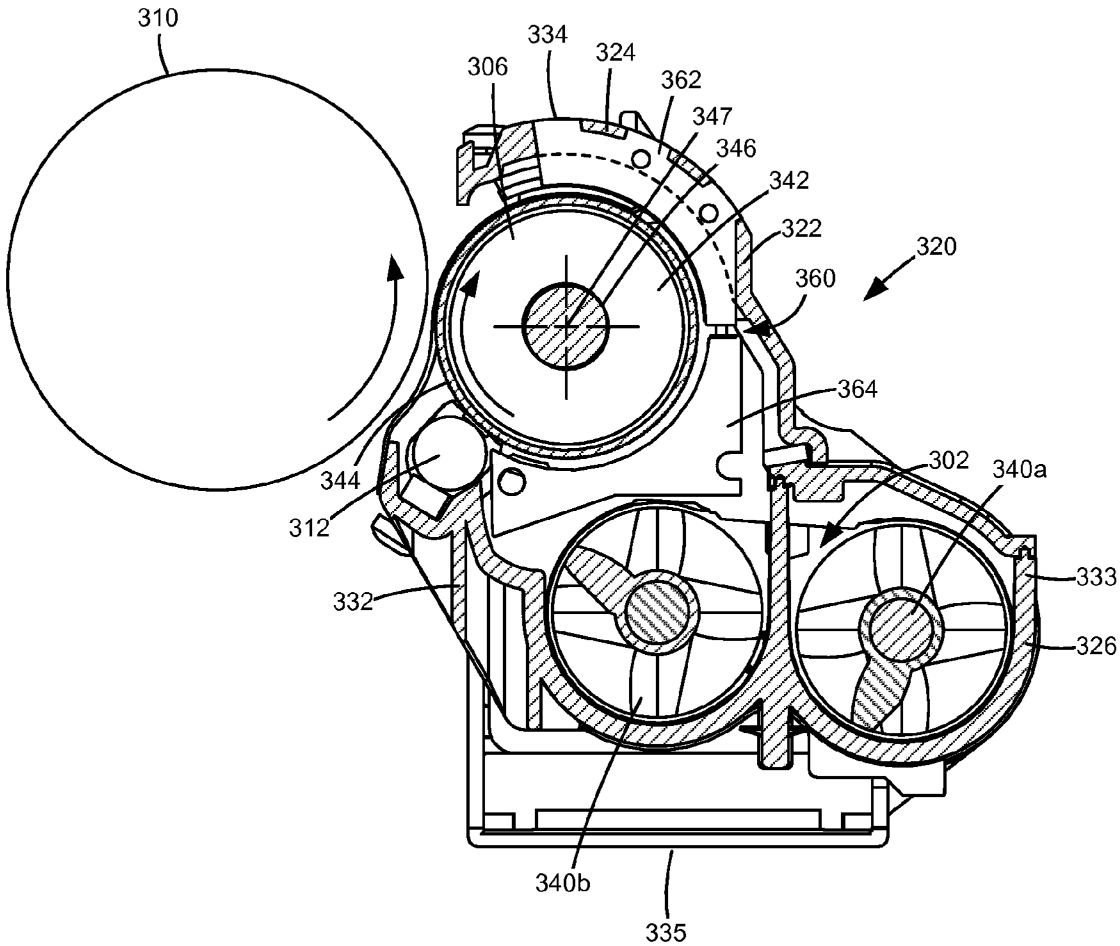
FIGURE 3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340b
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FIGURE 4

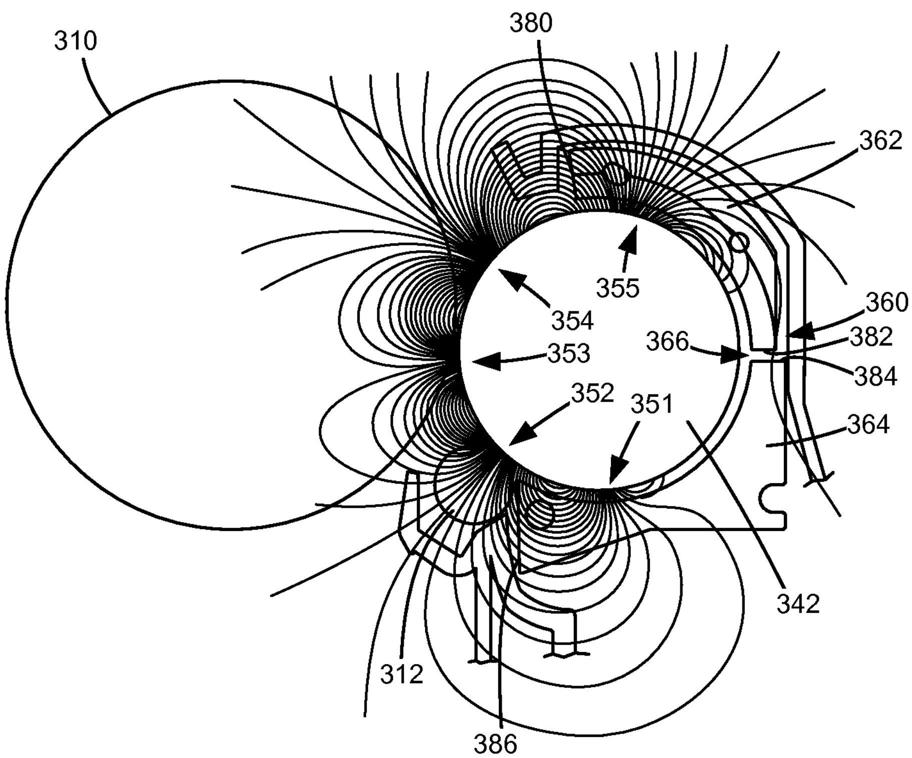

FIGURE 5

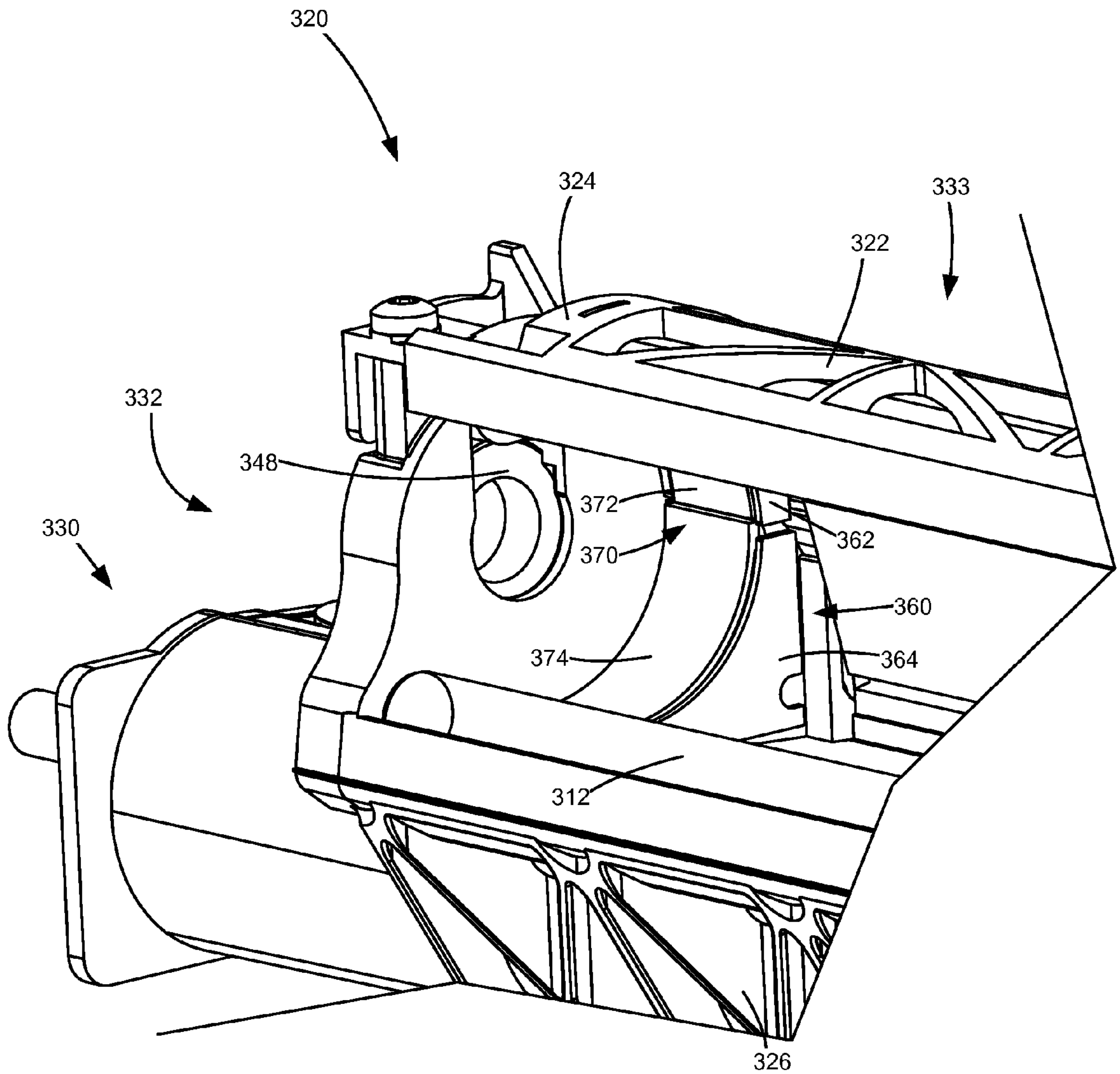

FIGURE 6

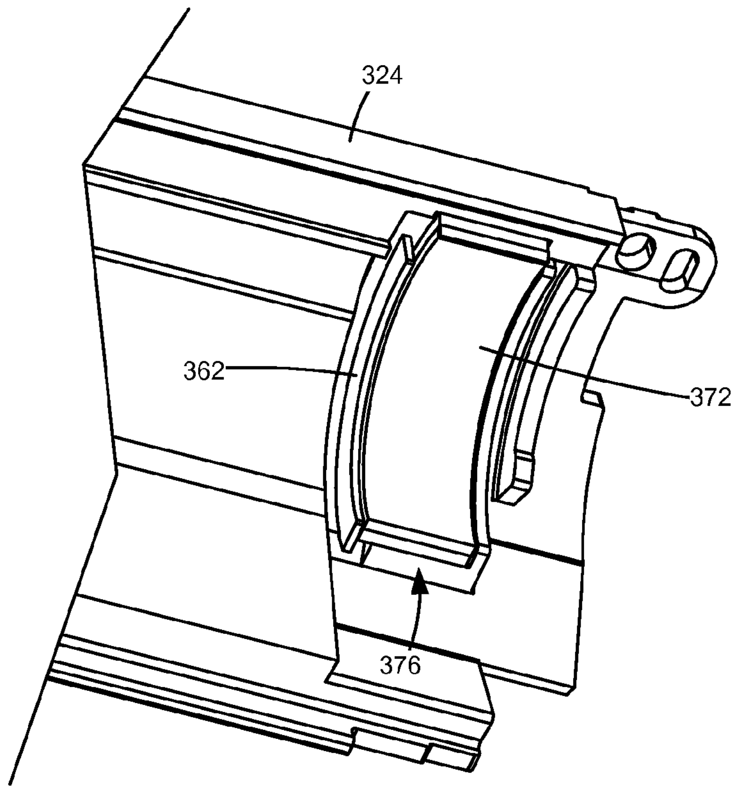

FIGURE 7

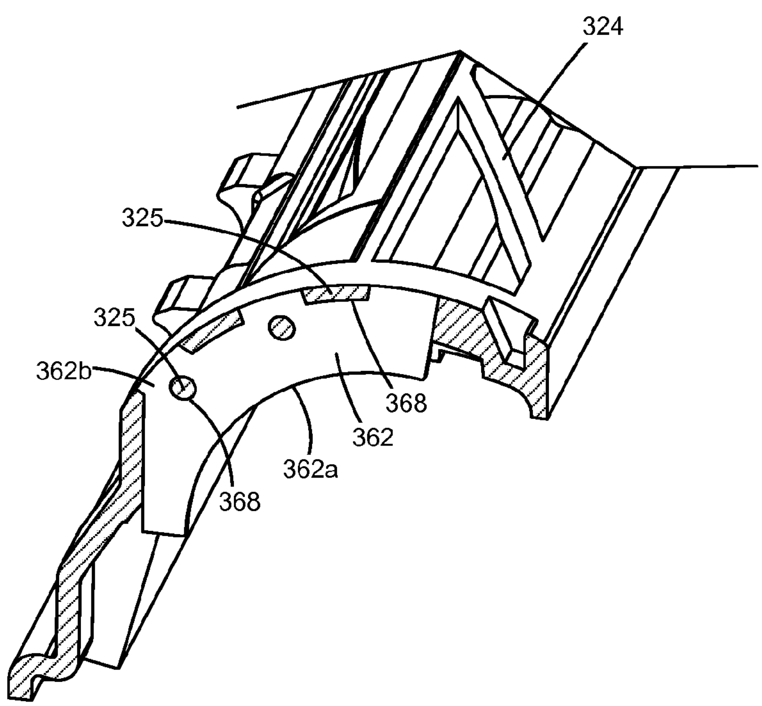

FIGURE 8

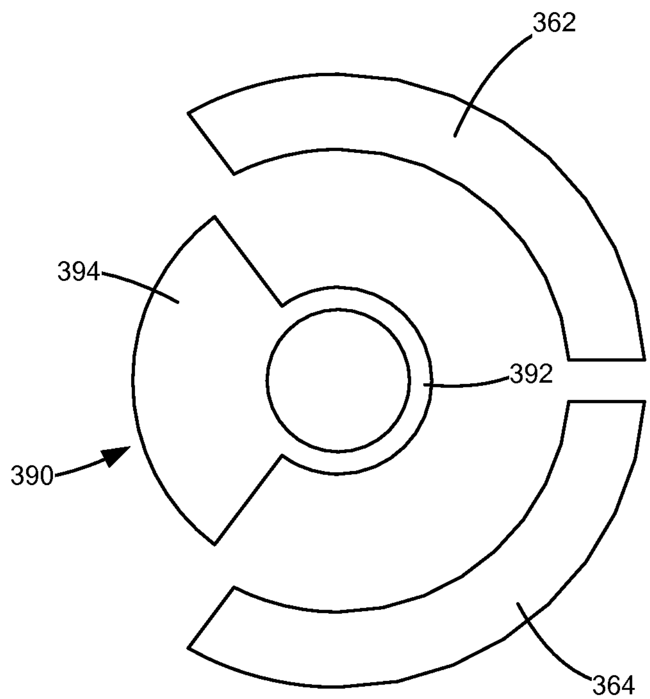

FIGURE 9

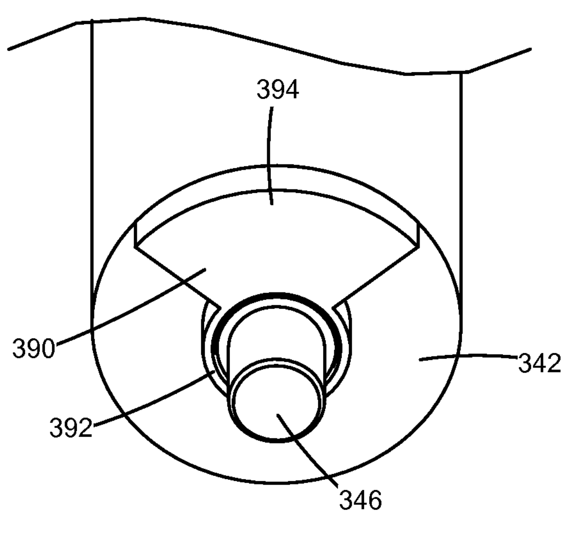

FIGURE 10

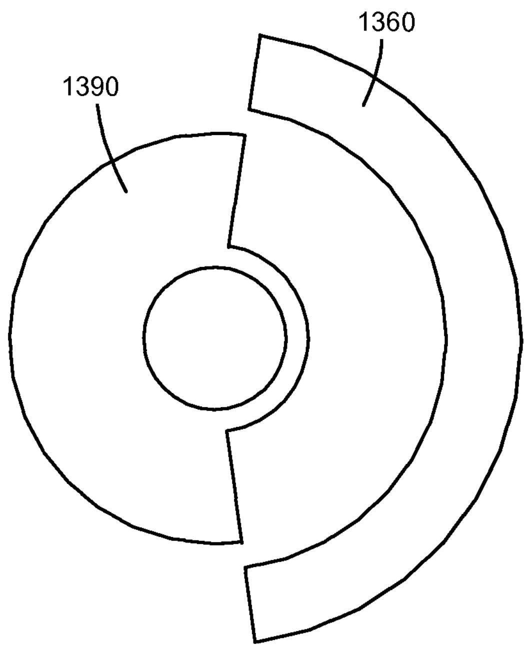

FIGURE 11

PARTIAL INTERNAL SHUNT AND PARTIAL EXTERNAL SHUNT ASSEMBLY FOR A MAGNETIC ROLL OF A DUAL COMPONENT DEVELOPMENT ELECTROPHOTOGRAPHIC IMAGE FORMING DEVICE

CROSS REFERENCES TO RELATED APPLICATIONS

None.

BACKGROUND

1. Field of the Disclosure

The present disclosure relates generally to image forming devices and more particularly to a partial internal shunt and partial external shunt assembly for a magnetic roll of a dual component development electrophotographic image forming device.

2. Description of the Related Art

Dual component development electrophotographic image forming devices include one or more reservoirs that store a mixture of toner and magnetic carrier beads. Toner is electrostatically attracted to the carrier beads as a result of triboelectric interaction between the toner and the carrier beads. A magnetic roll includes a stationary core having one or more permanent magnets and a sleeve that rotates around the core. The magnetic roll attracts the carrier beads in the reservoir having toner thereon to the outer surface of the sleeve through the use of magnetic fields from the core. A photoconductive drum in close proximity to the sleeve of the magnetic roll is charged by a charge roll to a predetermined voltage and a laser selectively discharges areas on the surface of the photoconductive drum to form a latent image on the surface of the photoconductive drum. The sleeve is electrically biased to facilitate the transfer of toner from the mix of toner and carrier beads on the outer surface of the sleeve to the discharged areas on the surface of the photoconductive drum forming a toner image on the surface of the photoconductive drum. The photoconductive drum then transfers the toner image, directly or indirectly, to a media sheet forming a printed image on the media sheet.

In general, the sleeve of the magnetic roll has a greater axial length than the core such that axial end portions of the sleeve extend past both axial ends of the core. The magnetic field lines from the core extend past the axial ends of the core and attract fine amounts of carrier beads and toner to the surface of the sleeve past the axial ends of the core. Toner from the surface of the sleeve past the axial ends of the core is generally not dense enough to form full quality images on the surface of the photoconductive drum. Accordingly, transfer of toner from the surface of the sleeve past the axial ends of the core to the surface of the photoconductive drum at the outer axial portions of the photoconductive drum is undesired.

The presence of unwanted carrier beads and toner on the surface of the sleeve past the axial ends of the core also increases the risk of leakage of carrier beads and toner from the system. During operation, carrier beads and toner may tend to accumulate on the outer axial end portions of the sleeve and leak past the axial ends of the sleeve potentially contaminating other parts of the system. Carrier beads and toner may also leak past the axial ends of the sleeve if a unit containing the reservoir and the magnetic roll is accidentally dropped during shipment of the unit.

One method to reduce the unwanted transfer of toner from the surface of the sleeve past the axial ends of the core to the surface of the photoconductive drum includes extending the length of the photoconductive drum and the charge roll in order to charge the surface of the photoconductive drum at the outer axial ends of the photoconductive drum to a voltage that will resist the charged toner. However, increasing the length of the photoconductive drum and the charge roll increases the cost and size of the system and does not address the leakage risk.

Another method to reduce the unwanted transfer of toner from the surface of the sleeve past the axial ends of the core to the surface of the photoconductive drum includes placing a magnetic shunt in the shape of a circular washer on a shaft of the magnetic roll and against each axial end of the core inside of the sleeve. This type of magnetic shunt is referred to as an internal shunt because it is positioned inside of the sleeve. Each internal magnetic shunt extends to the outer radial edge of the core around the entire circumference of the core. Each internal magnetic shunt is composed of a magnetically permeable metal that redirects the magnetic field lines from the axial ends of the core back into the core to decrease the distance that the magnetic field lines extend axially past the core. As a result, the internal magnetic shunts reduce the amount of carrier beads and toner on the surface of the sleeve past the axial ends of the core. However, these internal magnetic shunts do not address the leakage risk.

Accordingly, an improved method to reduce the amount of carrier beads and toner on the surface of the sleeve of a magnetic roll past the axial ends of the core of the magnetic roll and to reduce carrier bead and toner leakage is desired.

SUMMARY

A developer unit for a dual component development electrophotographic image forming device according to one example embodiment includes a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads. A magnetic roll includes a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation. The stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles. An outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the magnetic roll for transfer to a photoconductive drum and back to the reservoir. At least one external shunt is composed of a magnetically permeable metal and is positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core. At least one internal shunt is positioned at each axial end of the core inside of the sleeve. Each internal shunt has a shunt portion. The shunt portion is composed of a magnetically permeable metal and is positioned along a second circumferential portion of the core that contains substantially no angular overlap with the first circumferential portion.

A developer unit for a dual component development electrophotographic image forming device according to another example embodiment includes a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads. A magnetic roll includes a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation. The stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles. An outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the

magnetic roll for transfer to a photoconductive drum and back to the reservoir. At least one external shunt is composed of a magnetically permeable metal and is positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core that is not circumferentially aligned with the exposed portion of the magnetic roll. At least one internal shunt is positioned at each axial end of the core inside of the sleeve. Each internal shunt has a shunt portion. The shunt portion is composed of a magnetically permeable metal and is positioned along a second circumferential portion of the core that is circumferentially aligned with the exposed portion of the magnetic roll.

A developer unit for a dual component development electrophotographic image forming device according to another example embodiment includes a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads. A magnetic roll includes a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation. The stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles. An outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the magnetic roll for transfer to a photoconductive drum and back to the reservoir. At least one external shunt is composed of a magnetically permeable metal and is positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core but not in close proximity to the outer surface of the sleeve along a remaining second circumferential portion of the core. At least one internal shunt is positioned at each axial end of the core inside of the sleeve. Each internal shunt has a shunt portion. The shunt portion is composed of a magnetically permeable metal and is positioned along the remaining second circumferential portion of the core but not along the first circumferential portion of the core.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification, illustrate several aspects of the present disclosure, and together with the description serve to explain the principles of the present disclosure.

FIG. **1** is a block diagram depiction of an imaging system according to one example embodiment.

FIG. **2** is a schematic diagram of an image forming device according to one example embodiment.

FIG. **3** is a perspective view of a developer unit according to one example embodiment.

FIG. **4** is a cross-sectional view of the developer unit shown in FIG. **3**.

FIG. **5** is a schematic diagram of the developer unit of FIGS. **3** and **4** showing the magnetic field lines of a magnetic roll according to one example embodiment.

FIG. **6** is a perspective view of an end of the developer unit of FIGS. **3**-**5** with the magnetic roll removed according to one example embodiment.

FIG. **7** is a perspective view of an inner side of a lid of the developer unit of FIGS. **3**-**6** according to one example embodiment.

FIG. **8** is a cross-sectional view of the lid of the developer unit shown in FIG. **7** showing a magnetic shunt insert molded into the lid according to one example embodiment.

FIG. **9** is a schematic diagram of an arrangement of an external magnetic shunt and an internal magnetic shunt according to a first example embodiment.

FIG. **10** is a perspective end view of a magnetic roll core having the internal shunt shown in FIG. **9** installed on a shaft of the magnetic roll core according to one example embodiment.

FIG. **11** is a schematic diagram of an arrangement of an external magnetic shunt and an internal magnetic shunt according to a second example embodiment.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying drawings where like numerals represent like elements. The embodiments are described in sufficient detail to enable those skilled in the art to practice the present disclosure. It is to be understood that other embodiments may be utilized and that process, electrical and mechanical changes, etc., may be made without departing from the scope of the present disclosure. Examples merely typify possible variations. Portions and features of some embodiments may be included in or substituted for those of others. The following description, therefore, is not to be taken in a limiting sense and the scope of the present disclosure is defined only by the appended claims and their equivalents.

Referring now to the drawings and more particularly to FIG. **1**, there is shown a block diagram depiction of an imaging system **20** according to one example embodiment. Imaging system **20** includes an image forming device **100** and a computer **30**. Image forming device **100** communicates with computer **30** via a communications link **40**. As used herein, the term "communications link" generally refers to any structure that facilitates electronic communication between multiple components and may operate using wired or wireless technology and may include communications over the Internet.

In the example embodiment shown in FIG. **1**, image forming device **100** is a multifunction machine (sometimes referred to as an all-in-one (AIO) device) that includes a controller **102**, a print engine **110**, a laser scan unit (LSU) **112**, one or more toner bottles or cartridges **200**, one or more imaging units **300**, a fuser **120**, a user interface **104**, a media feed system **130** and media input tray **140** and a scanner system **150**. Image forming device **100** may communicate with computer **30** via a standard communication protocol, such as, for example, universal serial bus (USB), Ethernet or IEEE 802.xx. Image forming device **100** may be, for example, an electrophotographic printer/copier including an integrated scanner system **150** or a standalone electrophotographic printer.

Controller **102** includes a processor unit and associated memory **103** and may be formed as one or more Application Specific Integrated Circuits (ASICs). Memory **103** may be any volatile or non-volatile memory or combination thereof, such as, for example, random access memory (RAM), read only memory (ROM), flash memory and/or non-volatile RAM (NVRAM). Alternatively, memory **103** may be in the form of a separate electronic memory (e.g., RAM, ROM, and/or NVRAM), a hard drive, a CD or DVD drive, or any memory device convenient for use with controller **102**. Controller **102** may be, for example, a combined printer and scanner controller.

In the example embodiment illustrated, controller **102** communicates with print engine **110** via a communications link **160**. Controller **102** communicates with imaging unit(s) **300** and processing circuitry **301** on each imaging unit **300** via communications link(s) **161**. Controller **102** communicates with toner cartridge(s) **200** and processing circuitry **201** on each toner cartridge **200** via communications link(s) **162**. Controller **102** communicates with fuser **120** and processing circuitry **121** thereon via a communications link **163**. Controller **102** communicates with media feed system **130** via a communications link **164**. Controller **102** communicates with scanner system **150** via a communications link **165**. User interface **104** is communicatively coupled to controller **102** via a communications link **166**. Processing circuitry **121**, **201**, **301** may include a processor and associated memory, such as RAM, ROM, and/or NVRAM, and may provide authentication functions, safety and operational interlocks, operating parameters and usage information related to fuser **120**, toner cartridge(s) **200** and imaging units **300**, respectively. Controller **102** processes print and scan data and operates print engine **110** during printing and scanner system **150** during scanning.

Computer **30**, which is optional, may be, for example, a personal computer, including memory **32**, such as RAM, ROM, and/or NVRAM, an input device **34**, such as a keyboard and/or a mouse, and a display monitor **36**. Computer **30** also includes a processor, input/output (I/O) interfaces, and may include at least one mass data storage device, such as a hard drive, a CD-ROM and/or a DVD unit (not shown). Computer **30** may also be a device capable of communicating with image forming device **100** other than a personal computer, such as, for example, a tablet computer, a smartphone, or other electronic device.

In the example embodiment illustrated, computer **30** includes in its memory a software program including program instructions that function as an imaging driver **38**, e.g., printer/scanner driver software, for image forming device **100**. Imaging driver **38** is in communication with controller **102** of image forming device **100** via communications link **40**. Imaging driver **38** facilitates communication between image forming device **100** and computer **30**. One aspect of imaging driver **38** may be, for example, to provide formatted print data to image forming device **100**, and more particularly to print engine **110**, to print an image. Another aspect of imaging driver **38** may be, for example, to facilitate the collection of scanned data from scanner system **150**.

In some circumstances, it may be desirable to operate image forming device **100** in a standalone mode. In the standalone mode, image forming device **100** is capable of functioning without computer **30**. Accordingly, all or a portion of imaging driver **38**, or a similar driver, may be located in controller **102** of image forming device **100** on as to accommodate printing and/or scanning functionality when operating in the standalone mode.

FIG. **2** illustrates a schematic view of the interior of an example image forming device **100**. For purposes of clarity, the components of only one of the imaging units **300** are labeled in FIG. **2**. Image forming device **100** includes a housing **170** having atop **171**, bottom **172**, front **173** and rear **174**. Housing **170** includes one or more media input trays **140** positioned therein. Trays **140** are sized to contain a stack of media sheets. As used herein, the term media is meant to encompass not only paper but also labels, envelopes, fabrics, photographic paper or any other desired substrate. Trays **140** are preferably removable for refilling. A media path **180** extends through image forming device **100** for moving the media sheets through the image transfer process. Media path **180** includes a simplex path **181** and may include a duplex path **182**. A media sheet is introduced into simplex path **181** from tray **140** by a pick mechanism **132**. In the example embodiment shown, pick mechanism **132** includes a roll **134** positioned at the end of a pivotable arm **136**. Roll **134** rotates to move the media sheet from tray **140** and into media path **180**. The media sheet is then moved along media path **180** by various transport rollers. Media sheets may also be introduced into media path **180** by a manual feed **138** having one or more rolls **139**.

In the example embodiment shown, image forming device **100** includes four toner cartridges **200** removably mounted in housing **170** in a mating relationship with four corresponding imaging units **300**, which may also be removably mounted in housing **170**. Each toner cartridge **200** includes a reservoir **202** for holding toner and an outlet port in communication with an inlet port of its corresponding imaging unit **300** for transferring toner from reservoir **202** to imaging unit **300**. Toner is transferred periodically from a respective toner cartridge **200** to its corresponding imaging unit **300** in order to replenish the imaging unit **300**. In the example embodiment illustrated, each toner cartridge **200** is substantially the same except for the color of toner contained therein. In one embodiment, the four toner cartridges **200** include yellow, cyan, magenta and black toner.

Image forming device **100** utilizes what is commonly referred to as a dual component development system. Each imaging unit **300** includes a reservoir **302** that stores a mixture of toner and magnetic carrier beads. The carrier beads may be coated with a polymeric film to provide triboelectric properties to attract toner to the carrier beads as the toner and the carrier beads are mixed in reservoir **302**. Reservoir **302** and a magnetic roll **306** collectively form a developer unit. Each imaging unit **300** also includes a charge roll **308** and a photoconductive (PC) drum **310** and a cleaner blade or roll (not shown) that collectively form a PC unit. PC drums **310** are mounted substantially parallel to each other when the imaging units **300** are installed in image forming device **100**. In the example embodiment illustrated, each imaging unit **300** is substantially the same except for the color of toner contained therein.

Each charge roll **308** forms a nip with the corresponding PC drum **310**. During a print operation, charge roll **308** charges the surface of PC drum **310** to a specified voltage, such as, for example, −1000 volts. A laser beam from LSU **112** is then directed to the surface of PC drum **310** and selectively discharges those areas it contacts to form a latent image. In one embodiment, areas on PC drum **310** illuminated by the laser beam are discharged to approximately −300 volts. Magnetic roll **306** attracts the carrier beads in reservoir **302** having toner thereon to magnetic roll **306** through the use of magnetic fields and transports the toner to the corresponding PC drum **310**. Electrostatic forces from the latent image on PC drum **310** strip the toner from the carrier beads to form a toner image on the surface of PC drum **310**.

An intermediate transfer mechanism (ITM) **190** is disposed adjacent to the PC drums **310**. In this embodiment, ITM **190** is formed as an endless belt trained about a drive roll **192**, a tension roll **194** and a back-up roll **196**. During image forming operations. ITM **190** moves past PC drums **310** in a clockwise direction as viewed in FIG. **2**. One or more of PC drums **310** apply toner images in their respective colors to ITM **190** at a first transfer nip **197**. In one embodiment, a positive voltage field attracts the toner image from PC drums **310** to the surface of the moving ITM **190**. ITM **190** rotates and collects the one or more toner images from PC drums **310** and then conveys the toner images to a media sheet at a second transfer nip **198** formed between a transfer roll **199** and ITM **190**, which is supported by back-up roll **196**. The cleaner blade/roll removes any toner remnants on PC drum **310** so that the surface of PC drum **310** may be charged and developed with toner again.

A media sheet advancing through simplex path **181** receives the toner image from ITM **190** as it moves through the second transfer nip **198**. The media sheet with the toner image is then moved along the media path **180** and into fuser **120**. Fuser **120** includes fusing rolls or belts **122** that form a nip to adhere the toner image to the media sheet. The fused media sheet then passes through exit rolls **126** located downstream from fuser **120**. Exit rolls **126** may be rotated in either forward or reverse directions. In a forward direction, exit rolls **126** move the media sheet from simplex path **181** to an output area **128** on top **171** of image forming device **100**. In a reverse direction, exit rolls **126** move the media sheet into duplex path **182** for image formation on a second side of the media sheet.

While the example image forming device **100** shown in FIG. **2** illustrates four toner cartridges **200** and four corresponding imaging units **300**, it will be appreciated that a monocolor image forming device **100** may include a single toner cartridge **200** and corresponding imaging unit **300** as compared to a color image forming device **100** that may include multiple toner cartridges **200** and imaging units **300**. Further, although image forming device **100** utilizes ITM **190** to transfer toner to the media, toner may be applied directly to the media by the one or more photoconductive drums **310** as is known in the art. In addition, toner may be transferred directly from each toner cartridge **200** to its corresponding imaging unit **300** or the toner may pass through an intermediate component, such as a chute, duct or hopper, that connects the toner cartridge **200** with its corresponding imaging unit **300**.

Imaging unit(s) **300** may be replaceable in any combination desired. For example, in one embodiment, the developer unit and PC unit are provided in separate replaceable units from each other. In another embodiment, the developer unit and PC unit are provided in a common replaceable unit. In another embodiment, toner reservoir **202** is provided with the developer unit instead of in a separate toner cartridge **200**. For a color image forming device **100**, the developer unit and PC unit of each color toner may be separately replaceable or the developer unit and/or the PC unit of all colors (or a subset of all colors) may be replaceable collectively as desired.

FIGS. **3** and **4** show a developer unit **320** according to one example embodiment. Developer unit **320** includes a housing **322** having reservoir **302** therein. In the example embodiment illustrated, housing **322** includes a lid **324** mounted on a base **326**. Lid **324** may be attached to base **326** by any suitable construction including, for example, by fasteners (e.g., screws **328**), adhesive and/or welding. Housing **322** extends generally along an axial direction **307** of magnetic roll **306** from a first side **330** of housing **322** to a second side **331** of housing **322**. Side **330** leads during insertion of developer unit **320** into image forming device **100**. A portion of magnetic roll **306** is exposed at a front **332** of housing **322**. A handle **327** is optionally positioned on a rear **333** of housing **322** to assist with separating developer unit **320** from the corresponding PC unit. Housing **322** also includes a top **334** and a bottom **335**.

Reservoir **302** holds the mixture of toner and magnetic carrier beads (the "developer mix"). Developer unit **320** includes an inlet port **338** in fluid communication with reservoir **302** and positioned to receive toner from toner cartridge **200** to replenish reservoir **302** when the toner concentration in reservoir **302** relative to the amount of carrier beads remaining in reservoir **302** gets too low as toner is consumed from reservoir **302** by the printing process. In the example embodiment illustrated, inlet port **338** is positioned on top **334** of housing **322** near side **330**; however, inlet port **338** may be positioned at any suitable location on housing **322**.

Reservoir **302** includes one or more agitators to stir and move the developer mix. For example, in the embodiment illustrated, reservoir **302** includes a pair of augers **340***a*, **340***h*. Augers **340***a*, **340***b* are arranged to move the developer mix in opposite directions along the axial length of magnetic roll **306**. For example, auger **340***a* is positioned to incorporate toner from inlet port **338** and to move the developer mix away from side **330** and toward side **331**. Auger **340***b* is positioned to move the developer mix away from side **331**, in proximity to the bottom of magnetic roll **306** and toward side **330**. This arrangement of augers **340***a*, **340***b* is sometimes informally referred to as a racetrack arrangement because of the circular path the developer mix in reservoir **302** takes when augers **340***a*, **340***b* rotate.

With reference to FIG. **4**, magnetic roll **306** includes a core **342** that includes one or more permanent magnets and does not rotate relative to housing **322**. A cylindrical sleeve **344** encircles core **342** and extends along the axial length of magnetic roll **306**. Sleeve **344** has a greater axial length than core **342** such that axial end portions of sleeve **344** extend past both axial ends of core **342**. A shaft **346** passes through the center of core **342** and defines an axis of rotation **347** of magnetic roll **306**. Shaft **346** is fixed, i.e., shaft **346** does not rotate with sleeve **344** relative to housing **322**, and controls the position of core **342** relative to sleeve **344**. With reference back to FIG. **3**, a rotatable end cap **345** is positioned at one axial end of magnetic roll **306**, referred to as the drive side of magnetic roll **306**. End cap **345** is coupled to sleeve **344** such that rotation of end cap **345** causes sleeve **344** to rotate around core **342**. Sleeve **344** rotates in a clockwise direction as viewed in FIG. **4** to transfer toner from reservoir **302** to PC drum **310**. A drive coupler **350** is operatively connected to end cap **345** either directly, such as on an end of a shaft **349** that extends axially outward from end cap **345** as shown in the example embodiment illustrated, or indirectly. Drive coupler **350** is positioned to receive rotational force from a corresponding drive coupler in image forming device **100** when developer unit **320** is installed in image forming device **100**. Any suitable drive coupler **350** may be used as desired, such as a toothed gear or a drive coupler that receives rotational force at its axial end. In one embodiment, augers **340***a*, **340***b* are operatively connected to drive coupler **350** by one or more intermediate gears (not shown). Alternatively, augers **340***a*, **340***b* may be driven independently of drive coupler **350** and sleeve **344** by a second drive coupler positioned to receive rotational force from a corresponding drive coupler in image forming device **100** when developer unit **320** is installed in image forming device **100**.

With reference to FIGS. **4** and **5**, the permanent magnet(s) of core **342** include a series of circumferentially spaced, alternating (south v. north) magnetic poles that facilitate the transfer of toner to PC drum **310** as sleeve **344** rotates. FIG. **5** shows the magnetic field lines generated by the magnetic poles of core **342** according to one example embodiment. Core **342** includes a pickup pole **351** positioned near the bottom of core **342** (near the 6:00 position of core **342** as viewed in FIG. **5**). Pickup pole **351** magnetically attracts developer mix in reservoir **302** to the outer surface of sleeve **344**. The magnetic attraction from core **342** causes the developer mix to form bristle-like chains that extend from the outer surface of sleeve **344** along the magnetic field lines. In one embodiment, the outer surface of sleeve **344** includes a series of radially indented grooves or is otherwise roughened. The grooves extend axially along the outer surface of sleeve **344** and are spaced circumferentially from each other about the outer surface of sleeve **344**. The surface roughness of sleeve **344** promotes the formation of chains of developer mix with the bases of the chains tending to form in the grooves and minimizes slipping of the developer mix on the outer surface of sleeve **344**.

After the developer mix is picked up at pickup pole **351**, as sleeve **344** rotates, the developer mix on sleeve **344** advances toward a trim bar **312**. Trim bar **312** is positioned in close proximity to the outer surface of sleeve **344**. Trim bar **312** trims the chains of developer mix as they pass to a predetermined height defined by the gap between trim bar **312** and the outer surface of sleeve **344** in order to control the amount of developer mix on sleeve **344**. The surface roughness of the outer surface of sleeve **344** helps the developer mix pass trim bar **312**. Trim bar **312** may be magnetic or non-magnetic and may take a variety of different shapes including having a flat or rounded trimming surface. Core **342** includes a trim pole **352** positioned at trim bar **312** to stand the chains of developer mix up on sleeve **344** in a generally radial orientation for trimming by trim bar **312**. As shown in FIG. **5**, between pickup pole **351** and trim pole **352**, the chains of developer mix on sleeve **344** have a primarily tangential (as opposed to radial) orientation relative to the outer surface of sleeve **344** according to the magnetic field lines between pickup pole **351** and trim pole **352**.

As sleeve **344** rotates further, the developer mix on sleeve **344** passes in close proximity to the outer surface of PC drum **310**. As discussed above, electrostatic forces from the latent image formed on PC drum **310** by the laser beam from LSU **112** strip the toner from the carrier beads to form a toned image on the surface of PC drum **310**. Core **342** includes a developer pole **353** positioned at the point where the outer surface of sleeve **344** passes in close proximity to the outer surface of PC drum **310** to once again stand the chains of developer mix up on sleeve **344** in a generally radial orientation to promote the transfer of toner from sleeve **344** to PC drum **310**. The developer mix is less dense and less coarse when the chains of developer mix are stood up in a generally radial orientation than it is when the chains are more tangential. As a result, less wear occurs on the surface of PC drum **310** from contact between PC drum **310** and the chains of developer mix when the chains of developer mix on sleeve **344** are in a generally radial orientation.

As sleeve **344** continues to rotate, the remaining developer mix on sleeve **344**, including the toner not transferred to PC drum **310** and the carrier beads, is carried by magnetic roll **306** past PC drum **310** and back toward reservoir **302**. Core **342** includes a transport pole **354** positioned past the point where the outer surface of sleeve **344** passes in close proximity to the outer surface of PC drum **310**. Transport pole **354** magnetically attracts the remaining developer mix to sleeve **344** to prevent the remaining developer mix from migrating to PC drum **310** or otherwise releasing from sleeve **344**. As sleeve **344** rotates further, the remaining developer mix passes under lid **324** and is carried back to reservoir **302** by magnetic roll **306**. Core **342** includes a release pole **355** positioned near the top of core **342** along the direction of rotation of sleeve **344**. Release pole **355** magnetically attracts the remaining developer mix to sleeve **344** as the developer mix is carried the remaining distance to the point where it is released back into reservoir **302**. As the remaining developer mix passes the 2:00 position of core **342** as viewed in FIG. **5**, the developer mix is no longer magnetically retained against sleeve **344** by core **342** allowing the developer mix to fall via gravity and centrifugal force back into reservoir **302**. The surface roughness of the outer surface of sleeve **344** helps sleeve **344** retain the developer mix as the developer mix passes release pole **355** to the point where the developer mix is released back into reservoir **302**.

FIG. **6** shows an end portion of developer unit **320** near side **330** with magnetic roll **306** removed to more clearly illustrate the components positioned within housing **322** near the axial end of magnetic roll **306**. A bushing **348** is positioned at each axial end of magnetic roll **306** that receives a respective axial end of shaft **346**. Bushings **348** locate the ends of shaft **346**.

An external magnetic shunt assembly **360** that axially truncates the magnetic field at the axial ends of core **342** is positioned axially outboard of core **342**, just past each axial end of core **342**, in close proximity to a portion of the outer surface of sleeve **344** near each axial end of sleeve **344**. Magnetic shunt assemblies **360** are referred to as external because they are positioned outside of sleeve **344**. In the example embodiment illustrated, each shunt assembly **360** includes an upper magnetic shunt **362** and a lower magnetic shunt **364** as discussed in greater detail below. Each shunt **362**, **364** is composed of a magnetically permeable metal that pulls or redirects the magnetic field lines from the axial ends of core **342** back into core **342** to decrease the distance that the magnetic field lines extend axially past core **342**. As a result, shunts **362**, **364** decrease how far out axially the chains of developer mix form on the outer surface of sleeve **344**. In this manner, shunts **362**, **364** limit the amount of developer mix on sleeve **344** axially past the ends of core **342** and permit the use of a sleeve **344** having a smaller overall axial length as well as a charge roll **308** and PC drum **310** having smaller axial lengths. The reduction of developer mix past the axial ends of core **342** reduces the amount of toner that is inadvertently transferred to the outer axial portions of PC drum **310** beyond the axial ends of charge roll **308** thereby improving the print quality at the side margins of the printed page and improving toner yield by reducing the amount of toner lost to the outer axial portions of PC drum **310**. In one embodiment, the permeability of each shunt is at least 10 times the permeability of free space and may be between 100 and 1,000 times the permeability of free space or more.

During operation, the magnetic field lines redirected by shunts **362**, **364** at the axial ends of magnetic roll **306** cause a wall of developer mix to accumulate in the gaps between the outer surface of sleeve **344** and shunts **362**, **364**. The wall of developer mix forms a barrier to reduce the developer mix leaking axially outward from magnetic roll **306** or reservoir **302** and out of housing **322** at the axial ends of magnetic roll **306** during operation or in the event that developer unit **320** is dropped.

A magnetic seal assembly **370** is positioned in close proximity to a portion of the outer surface of sleeve **344** at each axial end of magnetic roll **306**, axially outboard of the magnetic shunt assembly **360** at each axial end of magnetic roll **306**. In the example embodiment illustrated, each seal assembly **370** includes an upper magnetic seal **372** positioned axially outboard from upper shunt **362** and a lower magnetic seal **374** positioned axially outboard from lower shunt **364**. In one embodiment, a thin plastic rib separates upper shunt **362** from upper magnetic seal **372** and lower shunt **364** from lower magnetic seal **374** at each axial end of magnetic roll **306**. Magnetic seals **372**, **374** each include a permanent magnet that attracts any developer mix that leaks axially outward past shunts **362**, **364** to reduce the developer mix leaking out of housing **322** at the axial ends of magnetic roll **306** during operation or in the event that developer unit **320** is dropped. Developer mix may tend to initially accumulate on the inner axial portions of magnetic seals **372**, **374** creating a barrier that reduces the developer mix leaking further axially outward. In one embodiment, the permanent magnet of each magnetic seal **372**, **374** includes a series of alternating (south v. north) magnetic poles that are axially offset from each other.

With reference to FIGS. **4**-**6**, in the example embodiment illustrated, upper shunts **362** and magnetic seals **372** are mounted on an inner surface of lid **324** proximate to the outer surface of sleeve **344** and lower shunts **364** and magnetic seals **374** are mounted on an inner surface of base **326** proximate to the outer surface of sleeve **344**. Shunts **362**, **364** and magnetic seals **372**, **374** curve around sleeve **344** in close proximity to the outer surface of sleeve **344**. Each upper shunt **362** is axially aligned with its corresponding lower shunt **364** and each upper magnetic seal **372** is axially aligned with its corresponding lower magnetic seal **374**. In the example embodiment illustrated, a starting point **380** (with respect to the direction of rotation of sleeve **344**), or front end, of upper shunts **362** and magnetic seals **372** is positioned between transport pole **354** and release pole **355** where the magnetic field from core **342** is more tangential than radial. In this region of the magnetic field, the chains of developer mix are more parallel to the outer surface of sleeve **344** than perpendicular to the outer surface of sleeve **344** as the chains of developer mix encounter starting point **380** of upper shunt **362** and magnetic seal **372**. As a result, less shearing of the chains of developer mix occurs at starting point **380** than if starting point **380** of upper shunts **362** and magnetic seals **372** was positioned where the magnetic field from core **342** is more radial than tangential where the chains of developer mix stand up more on the outer surface of sleeve **344**, **117** too much developer mix sheared at starting point **380** of upper shunts **362** and magnetic seals **372**, developer mix may tend to accumulate on the front edge of upper shunts **362** and/or magnetic seals **372** potentially causing leakage from the front **332** of housing **322**. In one embodiment, starting point **380** of upper shunts **362** and magnetic seals **372** is positioned at about the peak tangential point of the magnetic field from core **342** between transport pole **354** and release pole **355**.

An ending point **382** (with respect to the direction of rotation of sleeve **344**), or bottom end, of upper shunts **362** and magnetic seals **372** and a starting point **384** (with respect to the direction of rotation of sleeve **344**), or top end, of lower shunts **364** and magnetic seals **374** are positioned past the point where developer mix releases from the outer surface of sleeve **344** during rotation of sleeve **344**. Ending point **382** and starting point **384** are positioned above the point where the released developer mix reenters reservoir **302** (at about the top **334** of housing **322** above auger **340***a*), higher than the top of trim bar **312**. As a result, the released developer mix tends to fall from sleeve **344** toward reservoir **302** as it passes ending point **382** and starting point **384**, and may fall substantially vertically at about the 3:00 position of magnetic roll **306** as viewed in FIG. **5** (where the tangent to the outer surface of sleeve **344** is vertical) as it passes ending point **382** and starting point **384**. In one embodiment, a small gap **366** (e.g., ~1 mm) exists between ending point **382** of each upper shunt **362** and magnetic seal **372** and starting point **384** of each lower shunt **364** and magnetic seal **374**. Gaps **366** are positioned at the point where the developer mix released from sleeve **344** falls substantially vertically toward reservoir **302** at about the 3:00 position of magnetic roll **306** as viewed in FIG. **5** thereby reducing the likelihood of developer mix leaking through gap **366**. Further, the magnetic fields of upper magnetic seals **372** and lower magnetic seals **374**, regardless of their orientation (e.g., both north, both south, or one south and one north), tend to curve over and magnetically fill gaps **366** thereby also reducing the likelihood of leakage through gaps **366**.

An ending point **386** (with respect to the direction of rotation of sleeve **344**), or front end, of lower shunts **364** and magnetic seals **374** is positioned in close proximity to trim bar **312**. In one embodiment, a front end of each lower magnetic seal **374** touches the rear side of trim bar **312** to reduce leakage of developer mix between trim bars **312** and lower magnetic seal **374**.

In the embodiment illustrated, the combination of each upper shunt **362** and lower shunt **364** and the combination of each upper magnetic seal **372** and lower magnetic seal **374** surround greater than 180 degrees of the outer surface of sleeve **344** from starting point **380** to ending point **386**. For example, in one embodiment, the combination of each upper shunt **362** and lower shunt **364** and the combination of each upper magnetic seal **372** and lower magnetic seal **374** surround between 200 degrees and 260 degrees including all increments and values therebetween, such as about 221 degrees, of the outer surface of sleeve **344**.

With reference to FIGS. **7** and **8**, in one embodiment, each upper shunt **362** is insert molded into a plastic lid **324** of housing **320**. In this embodiment, a distal portion **362***a* of shunt **362** in proximity to the outer surface of sleeve **344** is exposed on the inner surface of lid **324** from starting point **380** to ending point **382**. A proximate portion **362***b* of shunt **362** is retained in lid **324**. As shown in FIG. **8**, in one example embodiment, shunt **362** includes retention holes **368** that are filled in with corresponding retention posts **325** on lid **324** during the molding process. The engagement between retention holes **368** and posts **325** enables precise positioning of shunt **362**. In other embodiments, shunt **362** is attached to lid **324** by other suitable methods, such as by adhesive, fasteners, friction fit, etc. Lower shunts **364** are also attached by any suitable method, such as by insert molding, adhesive, fasteners, etc. Upper shunts **362** and lower shunts **364** may be attached by the same method or shunts **362** may be attached to lid **324** differently than shunts **364** to base **326**.

With reference to FIG. **7**, in one embodiment, each magnetic seal **372**, **374** is attached by an adhesive to an inner surface of lid **324** and base **326** of housing **322**, respectively. In the example embodiment illustrated, magnetic seals **372**, **374** are each matably received in a recessed mounting pocket **376** on the inner surface of lid **324** and of base **326**, respectively. Mounting pockets **376** have a curved shape that matches the curvature of magnetic seals **372**, **374**. In other embodiments, magnetic seals **372**, **374** are mounted by other suitable means, such as by fasteners, friction fit, etc. Magnetic seals **372**, **374** may be composed of a flexible resin binder loaded with magnetic particles. The flexible resin binder may be manufactured flat and then bent upon attachment to housing **322**.

With reference to FIGS. **9** and **10**, in some embodiments, magnetic roll **306** includes an internal magnetic shunt **390** at each axial end of magnetic roll **306**. Internal shunts **390** are positioned against opposite axial ends of core **342** inside of sleeve **344**. Magnetic shunts **390** are referred to as internal because they are positioned inside of sleeve **344**. External shunts **362**, **364** and internal shunts **390** combine to axially truncate the magnetic field at the axial ends of core **342** around substantially the entire circumference of magnetic roll **306**. Internal shunts **390** redirect the magnetic field of core **342** along the area where magnetic roll **306** is exposed on the front **332** of housing **322**, where toner is transferred from magnetic roll **306** to PC drum **310**, at the axial ends of magnetic roll **306**. In one embodiment, each internal shunt **390** includes a thin (in the radial direction) circular ring **392** that fits around shaft **346**. FIG. **10** shows one of the internal shunts **390** positioned against one axial end of core **342** with ring **392** positioned around shaft **346**. Internal shunts **390** do not rotate with sleeve **344** relative to housing **322**. In one embodiment, each internal shunt **390** is fixed to the axial end of core **342** and/or to shaft **346**, such as by adhesive, keying or friction fit, in order to prevent the internal shunt **390** from rotating.

Each internal shunt **390** also includes a shunt portion **394** that extends in the radial direction to a position in close proximity to the inner surface of sleeve **344** at the radial edge of core **342**. Shunt portions **394** are composed of a magnetically permeable metal that pulls or redirects the magnetic field lines from the axial ends of core **342** back into core **342** as discussed above with respect to shunts **362**, **364**. As a result, internal shunts **390** decrease how far out axially the chains of developer mix form on the outer surface of sleeve **344** to limit the amount of developer mix on sleeve **344** axially past the ends of core **342**. In one embodiment, the permeability of each shunt portion **394** is at least 10 times the permeability of free space and may be between 100 and 1,000 times the permeability of free space or more. As shown in FIG. **9**, each shunt portion **394** is positioned along the circumferential portion of magnetic roll **306** that shunts **362**, **364** cannot reach without interfering with the toner transfer from magnetic roll **306** to PC drum **310**. For example, where the combination of upper shunts **362** and lower shunts **364** surrounds 220 degrees of magnetic roll **306**, each shunt portion **394** is positioned along substantially all of the remaining 140 degrees of magnetic roll **306**. The shunt portion **394** at each axial end of magnetic roll **306** does not overlap angularly with the external shunts **362**, **364** at that axial end of magnetic roll **306**. If a shunt portion **394** did overlap with one or more of the external shunts **362**, **364**, the shunt portion **394** would tend to cancel out the magnetic field truncation of the overlapped shunt **362** and/or **364** thereby defeating the purpose of the internal shunt **390** and the external shunts **362**, **364** in the overlapping region.

The example embodiment shown in FIGS. **9** and **10** shows each internal shunt **390** positioned in combination with an upper external shunt **362** and a lower external shunt **364** to provide axial magnetic field truncation along substantially the entire circumferential dimension of core **342** at a respective axial end of core **342**. However, any suitable combination of one or more external shunts and one or more internal shunts may be used at each axial end of core **342**. Each internal shunt(s) and external shunt(s) may be positioned along any suitable circumferential portion of core **342** on long as the external shunt(s) do not interfere with the toner transfer from magnetic roll **306** to PC drum **310**. For example, FIG. **11** shows a combination of an internal shunt **1390** and an external shunt **1360** according to another example embodiment. In this embodiment, an internal shunt **1390** is positioned along more than 180 degrees of core **342** at each axial end of magnetic roll **306** while an external shunt **1360** surrounds less than 180 degrees of sleeve **344** at each axial end of magnetic roll **306**. The combination of internal shunt(s) and external shunt(s) may be positioned along substantially the entire circumferential dimension of core **342** or less than the entire circumferential dimension of core **342** as desired.

The foregoing description illustrates various aspects and examples of the present disclosure. It is not intended to be exhaustive. Rather, it is chosen to illustrate the principles of the present disclosure and its practical application to enable one of ordinary skill in the art to utilize the present disclosure, including its various modifications that naturally follow. All modifications and variations are contemplated within the scope of the present disclosure as determined by the appended claims. Relatively apparent modifications include combining one or more features of various embodiments with features of other embodiments.

The invention claimed is:

1. A developer unit for a dual component development electrophotographic image forming device, comprising:
- a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads;
- a magnetic roll including a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation, the stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles, an outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the magnetic roll for transfer to a photoconductive drum and back to the reservoir;
- at least one external shunt composed of a magnetically permeable metal and positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core; and
- at least one internal shunt at each axial end of the core positioned inside of the sleeve and having a shunt portion, the shunt portion is composed of a magnetically permeable metal and positioned along a second circumferential portion of the core that contains substantially no angular overlap with the first circumferential portion.

2. The developer unit of claim **1**, wherein each of the at least one internal shunts is positioned against the respective axial end of the core.

3. The developer unit of claim **1**, wherein a sum of the first circumferential portion and the second circumferential portion is substantially the entire circumference of the core.

4. The developer unit of claim **1**, wherein the at least one external shunt and the at least one internal shunt at each axial end of the magnetic roll combine to axially truncate a magnetic field of the at least one permanent magnet along substantially the entire circumference of the core at each axial end of the magnetic roll.

5. A developer unit for a dual component development electrophotographic image forming device, comprising:
- a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads;
- a magnetic roll including a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation, the stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles, an outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the magnetic roll for transfer to a photoconductive drum and back to the reservoir;
- at least one external shunt composed of a magnetically permeable metal and positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core that is not circumferentially aligned with the exposed portion of the magnetic roll; and
- at least one internal shunt at each axial end of the core positioned inside of the sleeve and having a shunt portion, the shunt portion is composed of a magnetically permeable metal and positioned along a second circumferential portion of the core that is circumferentially aligned with the exposed portion of the magnetic roll.

6. The developer unit of claim **5**, wherein each of the at least one internal shunts is positioned against the respective axial end of the core.

7. The developer unit of claim **5**, wherein a sum of the first circumferential portion and the second circumferential portion is substantially the entire circumference of the core.

8. The developer unit of claim **5**, wherein the at least one external shunt and the at least one internal shunt at each axial end of the magnetic roll combine to axially truncate a magnetic field of the at least one permanent magnet along substantially the entire circumference of the core at each axial end of the magnetic roll.

9. A developer unit for a dual component development electrophotographic image forming device, comprising:

a housing having a reservoir for storing a developer mix that includes toner and magnetic carrier beads;

a magnetic roll including a stationary core and a sleeve positioned around the core that is rotatable relative to the core about an axis of rotation, the stationary core includes at least one permanent magnet having a plurality of circumferentially spaced magnetic poles, an outer surface of the sleeve is positioned to carry developer mix attracted to the outer surface of the sleeve by the at least one permanent magnet from the reservoir through an exposed portion of the magnetic roll for transfer to a photoconductive drum and back to the reservoir;

at least one external shunt composed of a magnetically permeable metal and positioned at each axial end of the magnetic roll axially outboard of the core and in close proximity to the outer surface of the sleeve along a first circumferential portion of the core but not in close proximity to the outer surface of the sleeve along a remaining second circumferential portion of the core; and

at least one internal shunt at each axial end of the core positioned inside of the sleeve and having a shunt portion, the shunt portion is composed of a magnetically permeable metal and positioned along the remaining second circumferential portion of the core but not along the first circumferential portion of the core.

10. The developer unit of claim **9**, wherein each of the at least one internal shunts is positioned against the respective axial end of the core.

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